Electrochemical Corrosion Protection Studies Pani/Ferrite/Alkyd Nanocomposite Coating

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Abstract: The electrochemical corrosion protection performance of polyaniline coated (Fe_3O_4) pigmented coating material has been studied in 3.5% NaOH and 3.5% HCl aqueous solutions by means of potentiodynamic polarization measurements. Previous studies on polyaniline/ferrite/alkyd nanocomposite coating were mostly concerned with quantitative analysis of corrosion prevention of mild steel. In present study, polyaniline coated Fe_3O_4 nanocomposite coating system has been examined its electrochemical corrosion prevention studies of mild steel in different aqueous solution. In pursuing our investigations, we found out polyaniline functionalized Fe_3O_4 particles into the polymer matrix (soya alkyd) for the formation of nanocomposite coating served as a topcoat for corrosion prevention of the mild steel substrates.

Key words: Materials · Potentiodynamic · Prevention · Electrochemical corrosion · Topcoat

INTRODUCTION

While the word corrosion has currently been applied to all kinds of materials in all sorts of environments, this article investigation will only consider the electrochemical corrosion control measures of mild steel in aqueous solutions at ambient temperatures based on potentiodynamic polarization measurements. It is probably the most commonly used polarization testing method for measuring corrosion resistance [1-4]. Corrosion of metals is still controlled by conventional methods like application of surface coating, use of inhibitors, besides the use of more corrosion resistant materials for specific application [5-7]. Very recently, Conducting polymers based blend/composites coatings have been showing the promising results for surface protection of metals and they are made to use as pigments at the place of inorganic pigments in concern to environment that is called a smart coating [8, 9]. The highest number of papers on the anticorrosion application of conducting polymers is associated with polyaniline (PANI) [4, 8-14], due to its high environmental stability and the easy and economic preparation [15]. Moreover,

one of the desirable end-goals of materials science research is the development of multi-functional materials [16-20]. Among the multi-functional materials, surface coated nanoparticles by means of conducting polyaniline in the corrosion protection of metals have recently gained momentum [20]. The functionalize iron black pigments (Fe_3O_4), which is not only used in the coating industry for qualified covering, coloration and light-resistance, but also widely in the construction industry due to its excellent alkali resistance [21-25], have been showing a potential results of corrosion inhibition on steel. The oxide layers are dense as well as more stable and act as a physical barrier that protects the metal surface from corrosion [26, 27]. Hence, it is envisaged that polyaniline-coated iron oxide containing coatings can exhibit better corrosion protection ability of mild steel. Earlier studies on polyaniline-Fe_3O_4 alkyd nanocomposite coating were mostly concerned with physicochemical and mechanical properties [28, 29]. Lately, In pursuing my investigation, I ascertained alkyd derived from soya oil containing polyaniline-Fe_3O_4 nanocomposite coating has profound role for corrosion protection coating materials. The electrochemical corrosion-protective performance was

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evaluated in terms of electro-chemical corrosion rate and corrosion inhibition efficiency in corrosion media i.e. 3.5% HCl, 3.5% NaOH aqueous solutions.

MATERIALS AND METHODS

Materials: Ferric chloride and ammonium hydroxide solution were purchased from S.D.Fine (Bombay) India, were of analytical grade and have been used for the preparation of polyaniline-Fe_3O_4 nanocomposite. Soya alkyd and melamine formaldehyde MF (Shankar Dyes, India), Xylene (Merck, India) and aniline monomer (Sigma, Aldrich) was double-distilled prior to use.

Potentiodynamic Polarization Measurements: Electrochemical corrosion tests of coating sample was also evaluated by potentiodynamic polarization measurements in HCl (3.5wt%) and NaOH (3.5wt%) at room temperature (30°C) using micro Autolab type III (μ3AVT 70762) potentiometer. The mild steel strips used for this studies were polished with silicon carbide papers of different grades (180, 320 and 500), followed by thorough rinsing with water, alcohol and acetone followed by drying with hot air blower in air. The Tafel plots in corrosive medium were obtained by using a three-electrode electrochemical cell containing platinum gauze as counter electrode, Ag/AgCl as reference electrode and test specimen (coated and uncoated mild steel strips) as working electrodes. The test specimens were fitted in electrochemical cell with 1 cm^2 area of the sample exposed to the corrosive media.

Synthesis of Pani Coated Fe_3O_4 Nanoparticles and Alkyd Coating Material: The synthesis of Fe_3O_4/PANI nanocomposite used for the preparation nanocomposite coating was reported in our earlier studies [7, 28, 29]. Accord to this, a fixed volume of ferrofluid was added drop wise to a 250 ml round bottom flask containing HCl (8 ml, 1N) and double distilled aniline (5 ml) with slow and continuous stirring maintained at a constant temperature and pH. After an induction period of 30 min, the color of the sol changed from red to green, which confirmed the polymerization of aniline in conducting form. Polymerization was further continued for 12 h at room temperature. The green precipitate of Fe3O4/PANI composite obtained was filtered, washed several times with distilled water, methanol and then dried in vacuum for 72 h at 60 1C. The synthesis of coating for the preparation of nanocomposite coating was prepared by mixing the 1.5 wt%. PANI coated Fe_3O_4 with 10 wt% alkyd solution in xylene.

RESULTS AND DISCUSSION

Potentiodynamic Polarization Measurements (Tofel Plot): Fig. 2 and 3 show the tofel plots of polyaniline coated Fe_3O_4 nanocomposite coating materials in 3.5% NaOH, 3.5% HCl respectively. The values of E_{cor}, I_{cor}, β-anodic, β-cathodic, corrosion rate and inhibition efficiency (IE%) were given in table 1. The properties of the PANI coated Fe_3O_4 alkyd coatings were found to be significantly enhanced with the loading of the polyaniline coated Fe_3O_4 pigments. It was observed that the coated
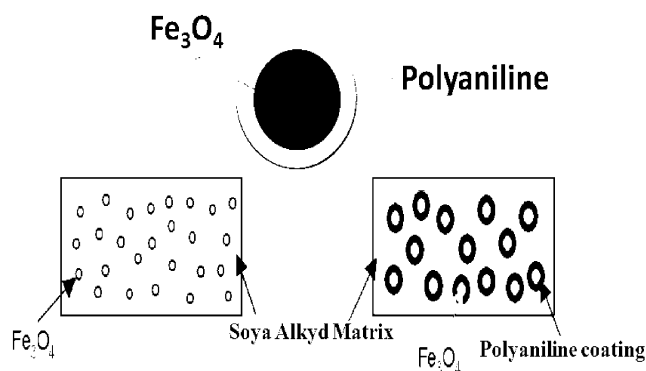

Fig. 1: Proposed polyaniline coated Fe_3O_4 nanoparticles and their dispersion into soya alkyd matrix

Table 1: Caption table 1 potentiodynamic polarization measurement results of PANI/ferrite/ alkyd nanocomposite coating

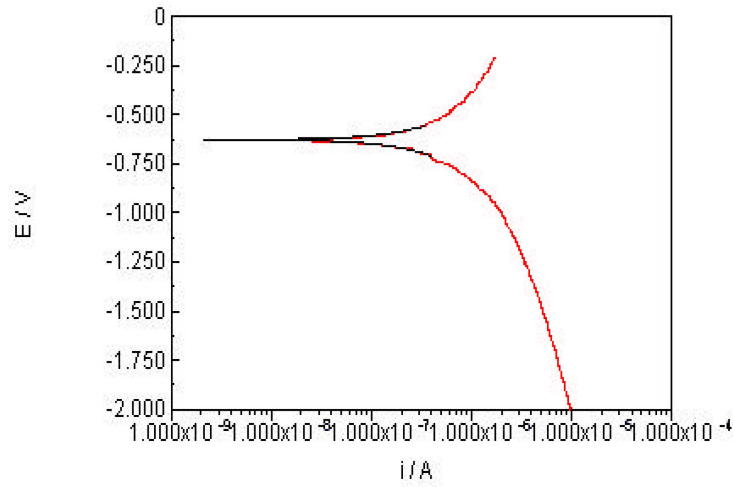| Sample	Medium	β-Anodic (V/dec)	β-Cathodic (V/dec)	E_{corr}(V)	I_{corr} (A/cm^2)	Corrosion rate(mm/year)	Inhibition Efficiency (IE%)
Mild Steel	3.5% HCl	0.064	0.096	-1.069	1.2×10^{-5}	1.48×10^{-1}	-
PANI/ferrite/ alkyd	3.5% HCl	.1252	0..2375	-0.647	7.566×10^{-6}	8.795×10^{-6}	82.85
Mild Steel	3.5% NaOH	0.049	0.160	-1.280	1.67×10^{-5}	1.94×10^{-1}	-
PANI/ferrite/ alkyd	3.5% NaOH	2.5112	2.6774	-0.653	8.391×10^{-9}	9.755×10^{-5}	79.12

Fig. 2: Tofel Plot of PANI/ferrite/ alkyd nanocomposite coating in 3.5 wt% HCl aqueous solution
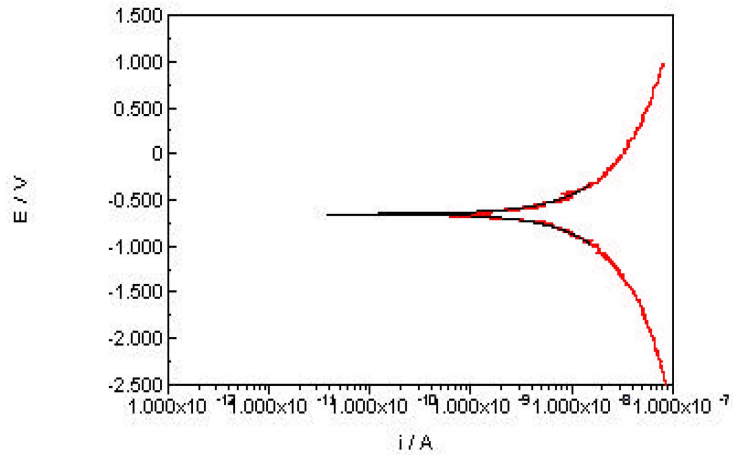

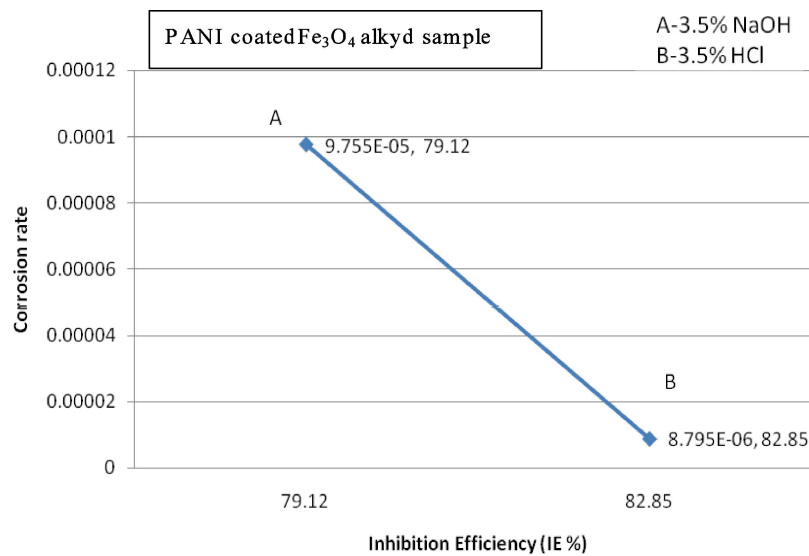Fig. 3: Tofel Plot of PANI/ferrite/ alkyd nanocomposite coating in 3.5 wt% NaOH aqueous solution

Fig. 4: Graph between inhibition efficiency and corrosion rate of PANI/ferrite/ alkyd nanocomposite coating

sample exhibited an excellent result in corrosive media in HCl and NaOH, indicating the good corrosion protective efficiency and reduction of corrosion rate. The inhibition efficiency IE (%) was also calculated by using following equation.

$$IE(\%) = \frac{Icorr - I'corr}{Icorr} \times 100$$

Where:

I_{corr} and I'_{corr} are the corrosion current densities obtained for coated and uncoated mild steel strips respectively.

CONCLUSION

PANI/ferrite/ alkyd nanocomposite coating based on nanotechnology approach was developed and it was found that nanocomposites coatings keenly able to effectively protect steel from electrochemical corrosion in acid and alkaline media. Having been excellent electrochemical corrosion resistance of this coating system, it can be predicted that surface modification of Fe_3O_4 nanoparticles through polyaniline is new approach for corrosion protection coating materials.

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